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(56) Documents cited
US 4686854 A US 4226693 A

(58) Field of search
UK CL (Edition K) G1N NBMR NBPR
INT CL[5] G01N

(54) **Transducer for corrosion or erosion measurement**

(57) A transducer 10 for corrosion or erosion measurement comprises an electrically conductive element 12 which is eroded or corroded, a temperature measuring sensor located adjacent element 12 and means for controlling the temperature of the conductive element by directing a stream of heated or cooled fluid through tube 22 to the rear of the conductive element.

The thickness of the conductive element 12 is calculated by compensating the measured resistance for the measured temperature of the conductive element using a micro-processor.

The fluid may be one or more of air, water or oil and the temperature sensing element may be a thermocouple, thermistor or a platinum resistance thermometer. The probe may be located in a boiler with its temperature reduced to the temperature of the furnace or boiler tubes by the control.

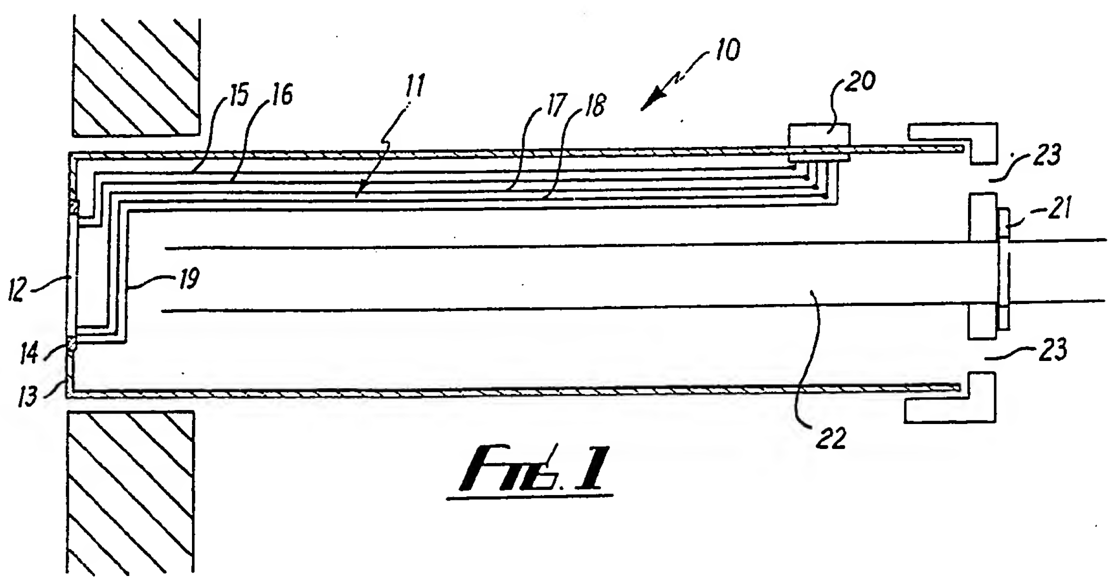

FIG. 1

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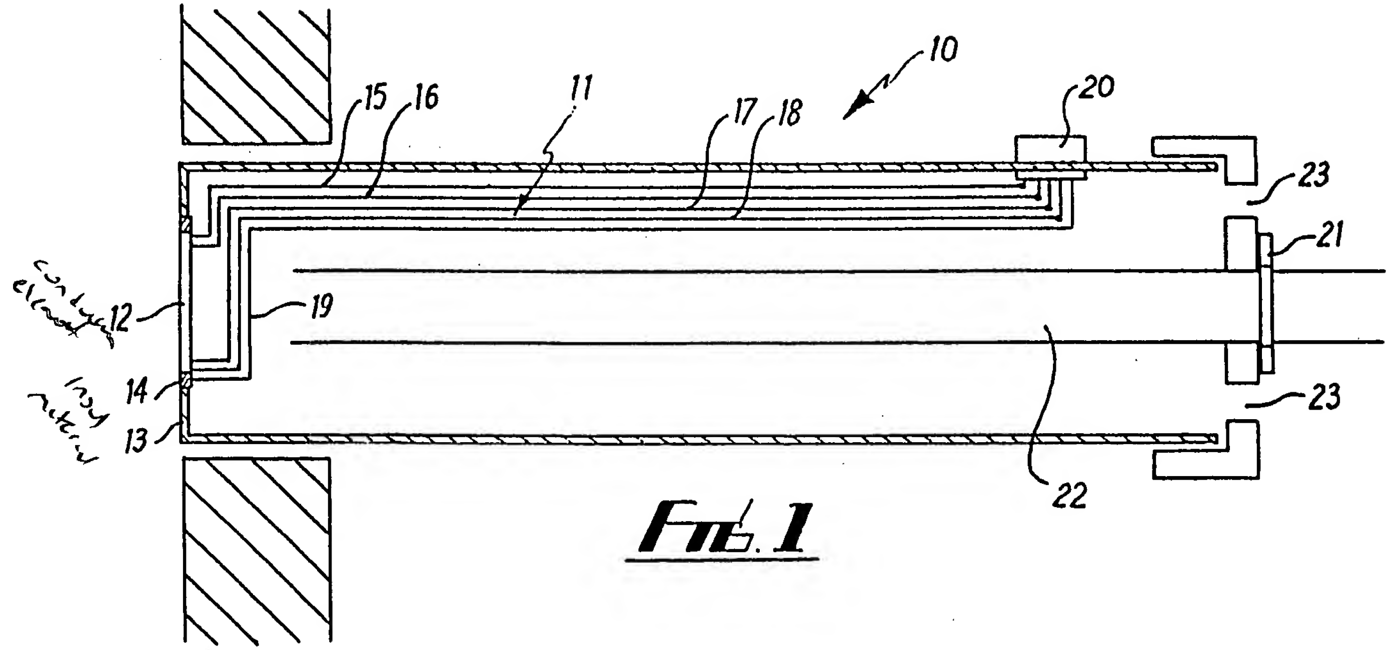

Fig. 1

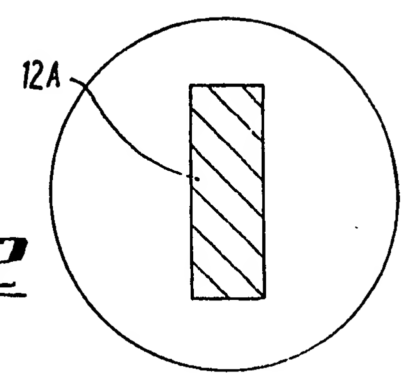

Fig. 2

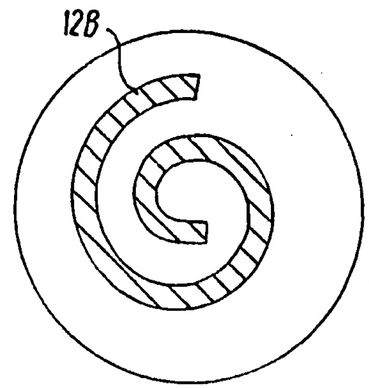

Fig. 3

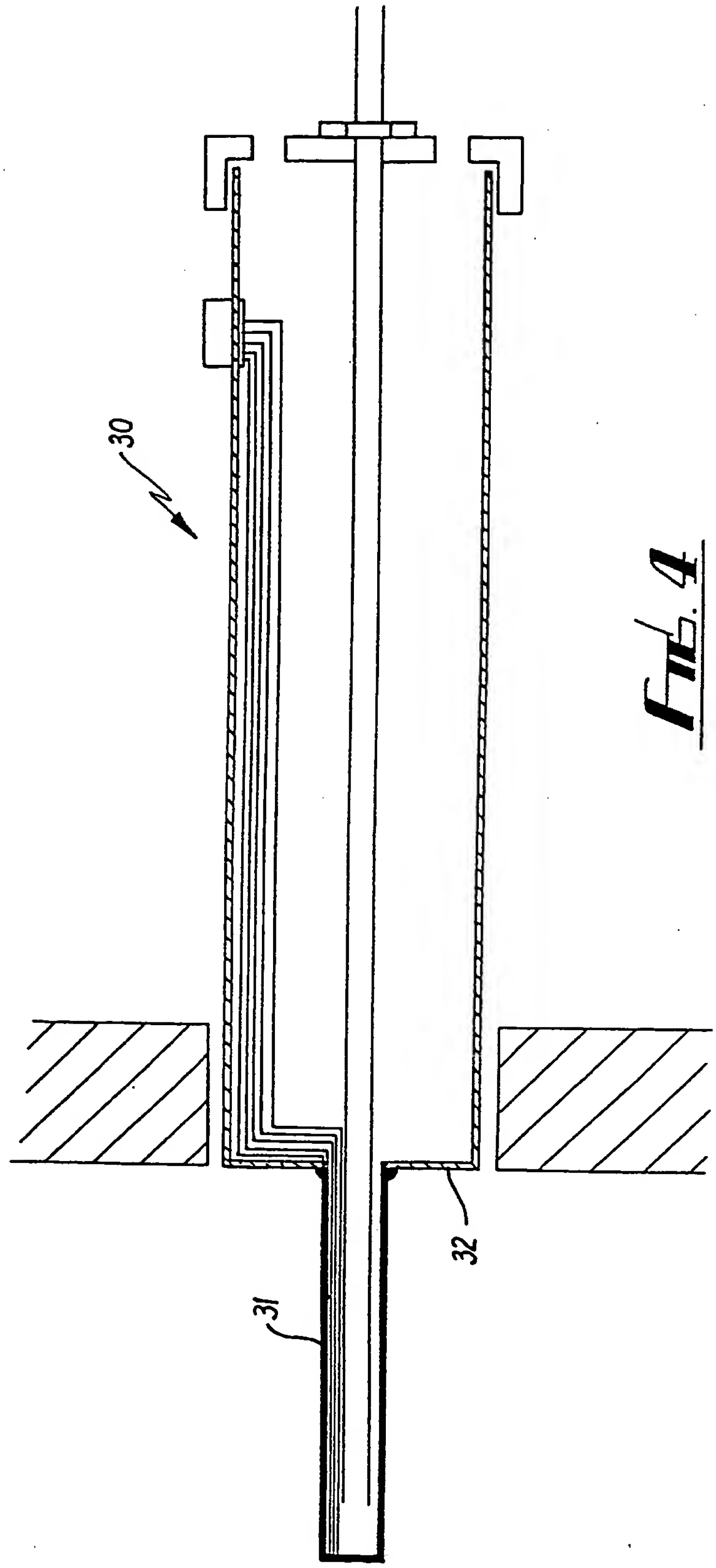

Fig. 4

TRANSDUCER FOR CORROSION OR EROSION MEASUREMENT

The present invention relates to a transducer for measuring the corrosion and/or erosion of an electrically conductive element, particularly, but not exclusively for use in gaseous or liquid environments.

It is known to measure the corrosion or erosion of the surface of a body of an electrically conductive material in a liquid or gaseous environment by measuring the thickness of a specimen of the material exposed to the same environment. Many transducers have been proposed to enable such measurements to be made, the transducer providing an electrical resistance measurement which is related to the thickness of the specimen.

Transducers normally comprise a first electrically conductive corrosion element in physical contact with the particular environment and a second electrically conductive reference element located in close proximity to the first element and at substantially the same temperature as it. The second element is physically isolated from the particular environment and serves as a reference ~~element to~~ enable temperature correction for the first element, this facilitates accurate thickness measurement of the

first element. The transducers also comprise a means for comparing the respective electrical resistances of the two elements typically using an a.c. or d.c. resistance bridge electronic circuit. The electrically conductive elements are typically made from wire, tube or thin strip.

Such transducers have been found to possess certain disadvantages.

The electrical resistance of an element is influenced by its temperature. In liquid or gaseous environments at temperatures significantly above or below the ambient external temperature a temperature gradient will become established along the length of the probe. Small but significant differences in temperature exist between the corrosion and the reference elements contained in the transducer which lead to significant errors in the resistance measurement. In liquid or gaseous environments at temperatures significantly above or below the ambient external temperature and subject to temperature variation, the differential in temperature between the corrosion and the reference elements will vary in accordance with the environmental temperature variation. In these environments, typified by the gaseous corrosive environments encountered in boiler, furnace and incinerator flue gas systems operating at

temperatures in the range 50° to ~~1200°C,~~ temperature related errors in the resistance measurement render the corrosion rate measuring technique useless.

In liquid or gaseous environments at temperatures significantly above or below the ambient temperature, erosion and corrosion is frequently encountered on heat transfer surfaces operating at significantly different temperatures to the bulk environment. In these environments, typified by air heater surfaces, water and steam tubes, condenser and cryogenic cooling surfaces, the transducer temperature will be different to that of the body surface to be simulated and the erosion or corrosion on the transducer will be different to that of the body surface of interest. Variation of the temperature of the transducer to equal that of the body is not possible due to the presence of the reference element. In addition, if variation of the temperature of the transducer was possible in these environments, the temperature of the corrosion element would be different to that of the reference element due to the latter being physically, and therefore thermally protected from the environment.

The present invention has been made from a consideration of these problems.

According to the present invention there is

provided a transducer for measuring the electrical resistance of an electrically conductive material exposed to a particular environment so as to monitor the corrosion and/or erosion thereof, said transducer comprising a temperature measuring device and an electrically conductive element, a surface of the electrically conductive element being operative to be in physical contact with said environment when the transducer is in use, the transducer being operative to be connected to a device for compensating the measured resistance of the conductive element for the measured temperature of the conductive element, wherein the transducer comprises a temperature control facility having means for directing a fluid towards the conductive element to vary the temperature thereof.

The transducer in accordance with the invention is particularly useful for measuring the corrosion on heat transfer surfaces, for example in steam-raising boilers, furnaces and refinery and petrochemical process plants. Corrosion of these surfaces can cause a decrease in heat transfer due to a build up of thermally insulating deposits, increased maintenance, replacement and downtime costs and an increased risk to safety in hazardous areas.

In a preferred embodiment of the invention the transducer comprises a single electrically conductive

element. No reference element is required.

The temperature measuring device is preferably provided in, on or adjacent the conductive element.

The resistance of the electrically conductive element is preferably measured using an a.c. or d.c. measuring device such as a micro-ohmmeter. The temperature of the conductive element may be measured using a high accuracy digital thermometer.

The thickness of the conductive element is calculated by compensating the measured resistance for the measured temperature of the conductive element using a suitable device such as a micro-processor.

The temperature control facility preferably comprises means for directing a fluid in the vicinity of the rear and/or sides of the conductive element. This fluid may comprise any fluid which may readily heat or cool the conductive element such as any of the following either alone or in combination: air, water, (liquid or steam) or oil. This enables the element to closely simulate the material of interest, for example a heat transfer surface located in the same environment as the probe. The temperature control facility can operate over a temperature range of at least 100°C such as 0-500°C or more.

The present invention provides a sensitive transducer which may be used in liquid or gaseous environments at operating temperatures above at or below the temperature of said environment and is capable of simulating heat transfer surfaces located in such environments.

In order that the invention may be more readily understood specific embodiments thereof will now be described by way of example only with reference to the accompanying drawings in which:-

Fig. 1 is a cross section through a probe comprising one transducer in accordance with the present invention;

Fig. 2 shows one possible conductive element of the transducer of Fig. 1;

Fig. 3 shows another possible conductive element of the transducer of Fig. 1; and

Fig. 4 is a cross sectional view through a second probe comprising a further transducer in accordance with the invention.

Referring to Figs. 1 to 3 a corrosion detecting

probe 10 housing a transducer 11 for measuring the corrosion and/or erosion of an electrically conductive material. The transducer 11 ~~comprises an~~ electrically conductive element 12 which is mounted in the front face 13 of the probe 10 by means of electrically insulating material 14. This insulating material 14 may comprise polymeric material for use at temperatures up to 300°C or a ceramic material for use of temperatures above 300°C. The electrically conductive element 12 may be in the form of a flush strip 12A as illustrated in Fig. 2 or a flush spiral element 12B as illustrated in Fig. 3. A pair of cables 15,16 is secured, for example, by welding to the top of the rear surface of the electrically conductive element 12.

(300 + 9/5) × 32
572 °F

Similarly a further pair of cables 17,18 is secured to the base of the rear surface of the electrically conductive element 12. One of the cables 15,17 of each pair is operative to a.c. or d.c. current. The other cables 16,18 are operative to measure the potential difference across the electrically conductive element.

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A temperature measurement sensor such as a thermocouple, thermister or platinum resistance thermometer is located in or adjacent to the electrically conductive element 12 so as to facilitate accurate temperature measurement of the element 12.

Leads 19 extend back from the temperature measurement sensor down the inside of the probe 10 and pass out of the probe 10 to an electrical connector 20. Likewise the cables 15,16,17,18 are fed down the probe 10 to the electrical connector 20. The electrical connector 20 is connected to resistance and temperature measurement and controller instruments (not shown).

The probe 10 further comprises a backplate 21 and an element temperature control facility. The element temperature control facility comprises a tube 22 extending to a position adjacent the element 12. The tube 22 may be used for carrying a heating/cooling medium such as air, water, steam or oil to the rear of the element 12 in order to maintain the desired element temperature. Exits 22 are provided in the backplate 21 of the probe 10 for the used temperature control medium. The temperature control medium therefore passes into the probe 10 via the inlet port of the tube 22 down the interior of the probe 10 and out through the exits 23 in the backplate 21 to be recirculated or vented to drain. High temperature resistant coatings may be provided on the leads 19 and cables 15,16,17,18 if required or else the leads 19 and cables 15,16,17,18 may be sealed off from the temperature control medium.

Referring to Fig. 4 there is shown a probe 30

similar to that described with reference to Fig. 1 except in that the electrically conductive element comprises a thin tube 31 of the material of interest which projects into the environment. The element may be welded directly onto the probe 32 as electrical isolation from the probe body is not required here.

In use the probes of Figs. 1 to 3 or Fig. 4 are located in a gaseous or liquid environment such as a furnace or a boiler. The temperature of the conductive element of the probe is adjusted, that is reduced, to be substantially the same as the temperature of the furnace or boiler tubes by way of the temperature control facility. Thus the conductive element simulates the conditions of the furnace or boiler tubes. The resistance and temperature of the conductive element are measured and the thickness of the conductive element is calculated by compensating the measured resistance for the measured temperature of the conductive element using a micro-processor.

Temperature compensation for the conductive element may be carried out as follows:-

<u>Example</u> - Temperature Compensation at 20°C

$$R_t = R_{293} (1 + \alpha t)$$

Where:

R_t = Resistance at test temperature, ohms.

R_{293} = Resistance at 20°C, ohms.

α = Temperature coefficient of resistance, K^{-1}

t = Test temperature - 293, K.

Calculation of the remaining element thickness at 20°C may be made as follows:-

$$D = \frac{\rho \times l}{W \times R_{293}}$$

Where:

ρ = Resistivity, ohm m.

l = Element length, m.

W = Element width, m.

D = Remaining element depth, m.

The probes are capable of accurately measuring a change in element thickness of 0.1 micrometer; this relates to the ability of the system to measure a high corrosion rate of 1.6 mm/y within 0.5 hr, or alternatively, a low corrosion rate of 0.2 mm/y within 4 hrs.

It is to be understood that the above described

embodiments have been described by way of illustration only. Many modifications and variations are possible.

CLAIMS

1. A transducer for measuring the electrical resistance of an electrically conductive material exposed to a particular environment so as to monitor the corrosion and/or erosion thereof, said transducer comprising a temperature measuring device and an electrically conductive element, a surface of the electrically conductive element being operative to be in physical contact with said environment when the transducer is in use, the transducer being operative to be connected to a device for compensating the measured resistance of the conductive element for the measured temperature of the conductive element, wherein the transducer comprises a temperature control facility having means for directing a fluid towards the conductive element to vary the temperature thereof.

2. A transducer as claimed in claim 1, wherein the temperature control facility comprises means for directing the fluid in the vicinity of the rear and/or sides of the conductive element.

3. A transducer as claimed in claim 1 or claim 2, wherein the fluid comprises any of the following either alone or in combination: air, water, and oil.

4. A transducer as claimed in any preceding claim,

wherein the temperature control facility can operate over a temperature range of at least 100°C.

5. A transducer as claimed in any preceding claim, wherein the temperature measuring device is located on or adjacent the conductive element.

6. A transducer as claimed in any preceding claim, wherein the temperature measuring device comprises any of the following either alone or in combination: a thermocouple, a thermister or a platinum resistance thermometer.

7. A transducer substantially as described herein with reference to Figs. 1 to 3 and Fig. 4.

8. A method of measuring corrosion or erosion on heat transfer surfaces using the apparatus of any of claims 1 to 7.

Patents Act 1977
Examiner's r port to the Comptroller under Section 17 (The Search Report)

Application number

GB 9213944.3

Relevant Technical fields

(i) UK Cl (Edition K) G1N (NBMR, NBPR)

(ii) Int Cl (Edition 5) G01N

Databases (see over)

(i) UK Patent Office

(ii)

Search Examiner

D J MOBBS

Date of Search

25 SEPTEMBER 1992

Documents considered relevant following a search in respect of claims 1-8

Category (see over)	Identity of document and relevant passages	Relevant to claim(s)
Y	US 4686854 (HERMAN)	1,8
Y	US 4226693 (MAES) see column 6 lines 5-6	1,8

SF2(p) TP - doc99\fil000436

Category	Identity of document and rel vant passages	Relevant to claim(s)

Categories of documents

X: Document indicating lack of novelty or of inventive step.

Y: Document indicating lack of inventive step if combined with one or more other documents of the same category.

A: Document indicating technological background and/or state of the art.

P: Document published on or after the declared priority date but before the filing date of the present application.

E: Patent document published on or after, but with priority date earlier than, the filing date of the present application.

&: Member of the same patent family, corresponding document.

Databases: The UK Patent Office database comprises classified collections of GB, EP, WO and US patent specifications as outlined periodically in the Official Journal (Patents). The on-line databases considered for search are also listed periodically in the Official Journal (Patents).

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